STUDIES ON THE GENUS AGROPYRON.

By Wilfred Robinson
Department of Field Crops,
University of Alberta,
Edmonton, Alberta.

April, 1928.

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A THESIS

submitted to the University of Alberta

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PRELIMINARY REMARKS.

The genus Agropyron is a group of annual or perennial grasses common to temperate regions of the northern hemisphere. Some species of this genus are very important forage plants on native grazing areas, while others are dangerous weeds on account of their vigourous growth and extensive underground rhizomes. In recent years several species have been brought under cultivation and have proven very valuable for hay and pasture purposes in certain regions. The selection and improvement of plants of this genus would appear to offer a fertile and virgin field of work for the plant breeder. Unfortunately, however, very little study of them has as yet been made. Therefore it was felt that a preliminary study or general survey of the genus should precede any attempts at improvement.

A knowledge of the variations that occur within the different species would give the plant breeder a sound basis to work upon. But he should also possess a knowledge of the lines of demarkation between species. The seed analyst, too, would be aided if enough data were accumulated to enable him to identify all specimens that were thought to be impurities

in commercial samples of seed. The natural mode of pollination of the plants in question will have a bearing on the methods that a plant breeder might employ, and should be investigated.

With these needs in mind the writer undertook a study of those species of the genus Agropyron either indigenous or introduced to the province of Alberta. Some work was also done in the province of Saskatchewan. The work is not yet completed, but considerable progress has been made.

Part I.

Morphological Variations and Ecological Relations of Species.

INTRODUCTION.

It is a generally accepted principle that no two individuals are exactly alike, that is, there are differences or variations which serve to distinguish one individual from another. Some of these variations will be fortuitous or due entirely to chance, while others will be due to a different inherent constitution. If we regard all individual plants as the product of a given inheritance working in a given environment we must regard any difference that we find between two individuals as due to either a different inheritance or a

different environment. The problem in hand was to discover what variations occurred within each species and the relation of these variations to the environment in which the plants were growing.

The purposes of this study has been to investigate as far as possible the various forms of Agropyron found in Alberta, giving special attention to the morphological variations and ecological relations of these forms, with the hope that this would provide a groundwork for a genetical study of the genus, and ultimately a basis for plant breeding work.

The investigation was commenced in June 1926 and continued as time permitted up to March 1928. While the University of Alberta may be regarded as the centre of the investigation, and it was there that most of the material was grown, the writer has studied the native Agropyrons over a wide section of Alberta and to some extent a portion of Saskatchewan. The area of territory covered extended south to Lethbridge and McLeod, north to Sangudo and Athabasca, and east to Scott, Saskatchewan.

Review.

Agropyron tenerum Vasey is described by Asa Gray (5) as follows. "Culms erect, 5-10 dm. high, rigid; leaves subrigid; narrow, flat or involute in drying; spike usually

almost cylindrical, green or straw-color, 1-1.5 dm. long; glumes firm, nearly as long as the spikelet, the sacarious margin narrow, tapering more gradually into the awned point; lemma short-awned. --------- The typical form has slender spikes with rather distant spikelets, --------- passing into a form with stouter and denser spikes and broader less rigid leaves ---------- essentially A. pseudorepens Scribn. and J. G. Sm." The description of this species as given by Britton and Brown (1) and Rydberg (12) is essentially the same as that given by Gray except that these authors regard A. pseudorepens as a distinct species, emphasizing the creeping rootstocks of the latter. Henry (7) refers to a long awned variety having been described as growing in mountainous regions. Whether this is A. tenerum or not it is not certain, perhaps she refers to A. Gmelini Scribn. and Smith. Clark and Malte (2) speak of the plant as having a very short root-stock, with the stems and sterile shoots strictly upright in habit. They further state that the outer glume (lemma) is " generally awnless but sometimes carries a short awn at its tip." Wide variations in size of plant, and amount and colour of foliage are also mentioned by these authors.

Agropyron Richardsonii Schrad according to Gray (4) is a tall stout plant distinguished by its large one-sided spike and long awned lemmas. He regards it as similar to A.

A

caninum (L) Beauv. Britton and Brown (1) list this species as being synonymous with A. caninum (L) R. and S. On the other hand Rydberg describes A. Richardsonii Schrad and states that it is scarcely distinct from A. caninum (L) of Europe. Clark and Malte (2) mention the species briefly emphasizing its one-sided spike and long awns.

It will be gathered from the foregoing that taxonomists are not agreed upon the distinctions between A. Richardsonii Schrad and A. caninum (L) Beauv. Under the circumstances it seems desirable at this point to present a description of A. caninum given by Gray (4) as follows: "Culms erect, 3-10 dm. high; leaves flat, rather lax, 8-20 cm. long, 2-6 mm. wide, scabrous; spike more or less nodding, at least in fruit;" again, "spike nodding, symmetrical." Spike, "rather dense, 7-15 cm. long; spikelets 1.3-1.5 cm. long exeluding the awns; glumes pointed or awned; lemmas 3-5 nerved; awns straight or somewhat spreading, fully twice the length of the lemma." Rydberg (12) mentions, "A. caninum Am. auth., mostly, "as synonymous with A. caninoides (Ramaley) Beal. The description of the latter species does not differ essentially from that given by Gray for A. caninum except that the spikes are said to be seldom unilateral.

Agropyron inerme (Scribn. and Smith) Rydb. is described by Rydberg (12). From this description it is only distin-

guished from A. tenerum by the spikelets being flattened instead of terete and the glumes being much shorter than the spikelets instead of nearly as long. The ranges of glume length given for both species overlap, i.e. A. tenerum 10-1? mm. A. inerme 8-10 mm.

Agropyron repens (L) Beauv, is well described by Britton and Brown (1) and Gray (4). Its chief characteristics are the strongly creeping rootstocks and the spike. It is easily distinguished from A. tenerum by the flattened spikelets which stand out from the rachis. The creeping habit also makes it conspicuous. Britton and Brown state that the lemmas are sometimes short-awned at the apex. Gray has found the awn to reach a length of 5 mm.

There is apparently no confusion over the identity of Agropyron Smithii Rydb. It is listed as synonymous with A. repens glaucum Scribn. in part, and A. Spicatum Scribn. and Sm. by Britton and Brown (1), Gray (4) and Rydberg (12) class it as synonymous with A. occidentale Scribn. The description given by Rydberg is as follows: "Stoloniferous plants with horizontal rootstocks---------. Stem 3-10 dm. high; leaf-blades spreading, rigid, bluish-green, glaucous, smooth or minutely scabrous beneath, becoming involute, 1-3 dm. long, 4-6 mm. wide; spike 7-18 cm. long; spikelets 7-13, flowered sometimes in pairs; lemma 8-12 mm. long, lanceolate, acute

or acuminate, seldom awn-pointed, smooth or nearly so" "Spikelets much flattened, spreading." To this we can add from Britton and Brown that the glumes are shorter than the spikelets and hispidulous on the keel and that the lemmas are sometimes sparsely pubescent; and from Gray that the lemmas may bear a very short awn.

Agropyron dasystachium (Hook.) Scribn. is described by Gray (4) as resembling A. repens. The plant being glaucous the leaves narrow and often involute; the spikelets 5-9 flowered usually subterete, densely pubescent except upon the strongly nerved glumes; the lemmas thinner than those of A. repens, with long acuminate apices. Britton and Brown (1) regard this species as synonymous with Agropyrun dasystachium Vasey, and Agropyron subvillosum E. Nels. They describe the glumes as, "3-5 nerved, lanceolate, acuminate or short-awned, 3-4.5 lines long;" the lemmas as, "broadly lanceolate, 5 nerved, 4.5-6 lines long, acute or short-awned, densely villous." Rydberg (12) describes the species in essentially the same manner as given above, except that he describes the lemma as long-villous, but he regards A. subvillosum E. Nels. as a distinct species. The only difference between A. dasystachium and A. subvillosum as given by Rydberg is that the lemmas of the latter are said to be densely pubescent instead of long villous.

The only descriptions of Agropyron albicans Scribn. and Smith, and Agropyron Griffithsii Scribn. and Smith which have come to hand are those of Rydberg (12). These two species have no synonyms and are only separated from each other by the lemmas of A. albicans being pubescent and those of A. Griffithsii glabrous. Rydberg's descriptions are as follows: A. albicans, stoloniferous plants with horizontal rootstocks; lemmas pubescent, with a long more or less divergent awn. "Stem erect, 3-6 dm. high, glaucous; leaf-blades rigid, ascending, involute, scabrous, 7-20 cm. long, 2-3 mm. wide; spike slightly nodding, 7-10 cm. long; spikelets 8-10, 5-7 flowered, 15-18 mm. long; empty glumes pubescent, oblanceolate, acuminate, tipped with an awn 4-6 mm. long; lemma about 9 mm. long, ovate lanceolate; awn 12-15 mm. long." A. Griffithsii. Stoloniferous plants with horizontal rootstocks; lemmas glabrous, with a more or less divergent awn. "Stem glabrous, 3-8 dm. high, striate; leaf-blade rather rigid, mostly involute, 5-10 cm. long; spike erect, 8-15 cm. long; spikelets pale, closely 5-7 flowered; empty glumes 8 mm. long, with awns 3 mm. long; lemma oblong, 8-10 mm. long; awns 8-10 mm. long."

Agropyron pungens (Pers.) R. and S. as described by Britton and Brown (1) is a glaucus plant with slender, erect rigid culms 4,5-9 dm. high, growing from a running rootstock; leaf-blades erect acuminate, smooth beneath, glaucous above,

scabrous on the margins; spikes 8-10 cm. long, 4 sided; spikelets dense, 6-11 flowered, 1.3 to 2 cm. long, appressed to the rachis; rachis 4 angled, articulated, hispidulous on the angles; glumes lanceolate 10 mm. long, rough on the keel, 5-7 nerved; lemmas lanceolate, keeled, rough towards the apex, acute to short awned. Synonymous with A. tetrastachys Scribn. and Sm. This description is in keeping with that presented by Gray (4).

After perusing the available literature one is forced to the conclusion that the lines of demarkation between certain species of Agropyron are by no means clearly defined. Apparently one may expect to find a wide range of variation in each and in some cases gradations from one species to another. Thus one cannot be certain whether A. pseudorepens is a distinct species or only an extreme form of A. tenerum. Undoubtedly the forms variously described as A. Richardsonii, A. caninum, and A. caninoides, must be very similar. From the descriptions the forms seem to overlap, so that it would not be unreasonable to suppose that perhaps they all belong to the same species. A. dasystachium and A. subvillosum present the same difficulty in the matter of identification. If either form were to vary even slightly in the direction of the other it would be very hard to decide to which species it belonged. The same is true of the distinctions between

A. albicans and A. Griffithsii. The most marked distinctions that one could hope to find would be that A. albicans has pubescent glumes and a slightly longer awn, while A. Griffithsii is said to be somewhat the taller of the two. Although the other species mentioned have in some cases been variously described one would not expect, from the literature, to encounter any difficulty in identification.

INVESTIGATION.

Materials.

The plant material used in this study was obtained in the main from three sources. first, material growing on the University farm at the time the project was started; second, material collected by the writer from native habitats and cultivated fields; third, material collected and placed at the writer's disposal by other people. Pure cultures of Agropyron tenerum, A. Smithii, and A. crystatum were being grown at the University of Alberta in 1926, and these were made available for purposes of this investigation. Several thousand specimens were collected for laboratory study and used in this work. Attempts were made to secure seed of species not indigenous to Alberta, but the only seed obtained was Agropyron pungens, from Suttons of Reading, England. Mr. E. C. Stacey of

Beaverlodge provided seeds of A. inerme (which had been identified by Dr. A. S. Hitchcock), and kindly gave permission to use the herbarium specimens which he had collected in the Peace River district. Miss M. Reith provided specimens of several species growing wild at Wembley, Alberta. Very valuable assistance was given by the late Victor Matthews of the Experimental Station Scott, Saskatchewan, who gave permission to study 56 strains of A. tenerum that were being grown at that station. These were strains selected by Dr. M. C. Malte, and were said to have been propogated from individual plants.

Methods.

For the study of morphological characters field trips were made in the Edmonton district in 1926. Plants of the species native to the district were studied in their natural habitats, and typical or widely variant plants were transplanted to the University farm. This transplantation was made in order that the plants might grow in as uniform an environment as possible. Lack of time and other factors made this work rather limited but during this season the district was fairly well covered and about sixty plants removed to the farm. During that summer some individual plants of Agropyron tenerum of the strain "Malte's no. 4" were examined and a few

selections made. Seed from five of these selected plants was sown in head rows late in August 1926 in order that the progeny might be studied in 1927. In the winter of 1926-1927 a few plants were grown in the greenhouse. These included plants grown from the seed of a specimen secured at Marsden, Saskatchewan in October 1926 and seedlings of A. inerme and A. pungens. These plants were transferred to the field in the spring of 1927.

The field trips were continued in the summer of 1927, a large portion of Alberta and a part of Saskatchewan being visited. On these trips plants were collected, with notes on their habitats and kept for identification. A special trip was made to the Dominion Experimental Station at Scott, Saskatchewan. Here fifty-six strains of Agropyron tenerum were studied. About one hundred plants were taken from each plot and reserved for examination.

Description.

Plants which were selected for transplantation were dug up by the roots and after cutting off the above-ground parts replanted in the plot on the University farm. The roots of all the plants were trimmed down to about the same size. They were all transplanted at about the same stage of development and were placed as far as possible under equal conditions.

All were spaced 30 inches apart each way. This procedure presumably gave each plant an equal opportunity to express its inherent potentialities. Those which were transplanted in 1926 made fair growth that year and attained normal development in 1927.

Notes having been taken on these plants in their natural habitats and during their growth in the field, it was possible to observe the effects of a changed environment on the development of various characters. Some 48 plants of Agropyron tenerum, ten plants of A. caninum, and twelve plants of A. crystatum were treated in this manner.

The plants grown from seed were treated in a manner very similar to those transplanted from their native habitats. The seed of the five selected plants of "Malte's no. 4" was sown in August 1926. The plants were grown singly, 30 inches apart each way. Fifty plants of each selection were grown, but during the winter of 1926-1927 several died in each row so that only 41 to 48 plants were considered in each. These plants were permitted to mature in 1927 and the longest culm of each was pulled out and retained for detailed examination. Seeds of the selection made at Marsden, Saskatchewan, seeds of Agropyron inerme, and of A. pungens were sown in sterile soil in pots in the greenhouse during the winter of 1926-1927. After they had attained some growth they were planted in a bed

[illegible]

[illegible] plants [illegible] varieties [illegible]. [illegible] plants of [illegible]

[illegible], ten plants of L. [illegible], and twelve plants of [illegible]

[illegible]

The plants [illegible] from some way [illegible]

[illegible] to those [illegible] from their native [illegible].

[illegible] of the first [illegible]

[illegible] way. Fifty plants of each [illegible] were [illegible]

during the winter of 1921-1922 several died in [illegible]

so that only 41 to 46 plants [illegible]

[illegible]

with fairly deep soil, and transplanted to the field in May 1927. These were examined and treated as previously mentioned for other plants. They were started in the greenhouse because the seed was not secured until it was too late to plant them outside in 1926.

During the summer of 1927 the writer had occasion to travel through various sections of Alberta and Saskatchewan. One of these trips was made to Scott, Saskatchewan for the express purpose of securing material for this investigation. In driving through the country notes were taken on the species of Agropyron present. At intervals of varying lengths areas were examined in detail and specimens of all the species and forms of Agropyron growing there were collected. These plants were always removed with the roots intact, and kept for future reference. In this way a general knowlege of the distribution of the various species, and a detailed knowlege of the forms growing in certain areas was acquired. All these plants were later identified and listed. In taking the samples from the plots at Scott one hundred plants from each were chosen at random, and the longest culm of each removed with the roots. In the laboratory they were examined to determine the variation within and between each strain.

Where statistical treatment of quantitative data was considered necessary the methods of Jones (9) or Hayes and Garber (6) were employed. All identifications are based on

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Where statistical treatment of quantitative data was considered necessary the methods of Fisher (8) or Hayes and Garber (6) were employed. All the [illegible]

the authority of Dr. A. S. Hitchcock, of the Smithsonian Institution.

FINDINGS.

Distributions and Habitats.

The following species of Agropyron were observed growing in the area covered by this investigation. Agropyron tenerum Vasey, A. caninum (L) Beauv. A. inerme (Scribn. and Smith) Rydb. A. repens (L) Beauv. A. Smithii Rydb. A. dasystachium (Hook.) Scribn. A. albicans Scribn. and Smith, A. Griffthsii Scribn. and Smith. They were distributed as stated below and as shown on the accompanying map (fig.1).

The species Agropyron pungens (Pers.) R. and S. and A. crystatum ---- were studied only on the University farm, and are included here only for the sake of completeness.

Agropyron tenerum was found growing wild throughout the area covered. It was found growing in Stipa-Bouteloua associations near McLeod, frequently with the "prairie wool" of the plains, and in damp places and under the shade of trees both in the "park belt" and in the heavily-wooded regions of the more northern sections. It appears to be adapted to almost any soil or condition excepting ground that is subject heavy spring flooding. In regions where the forest growth is driving out herbaceous plants it seems to be one of the last

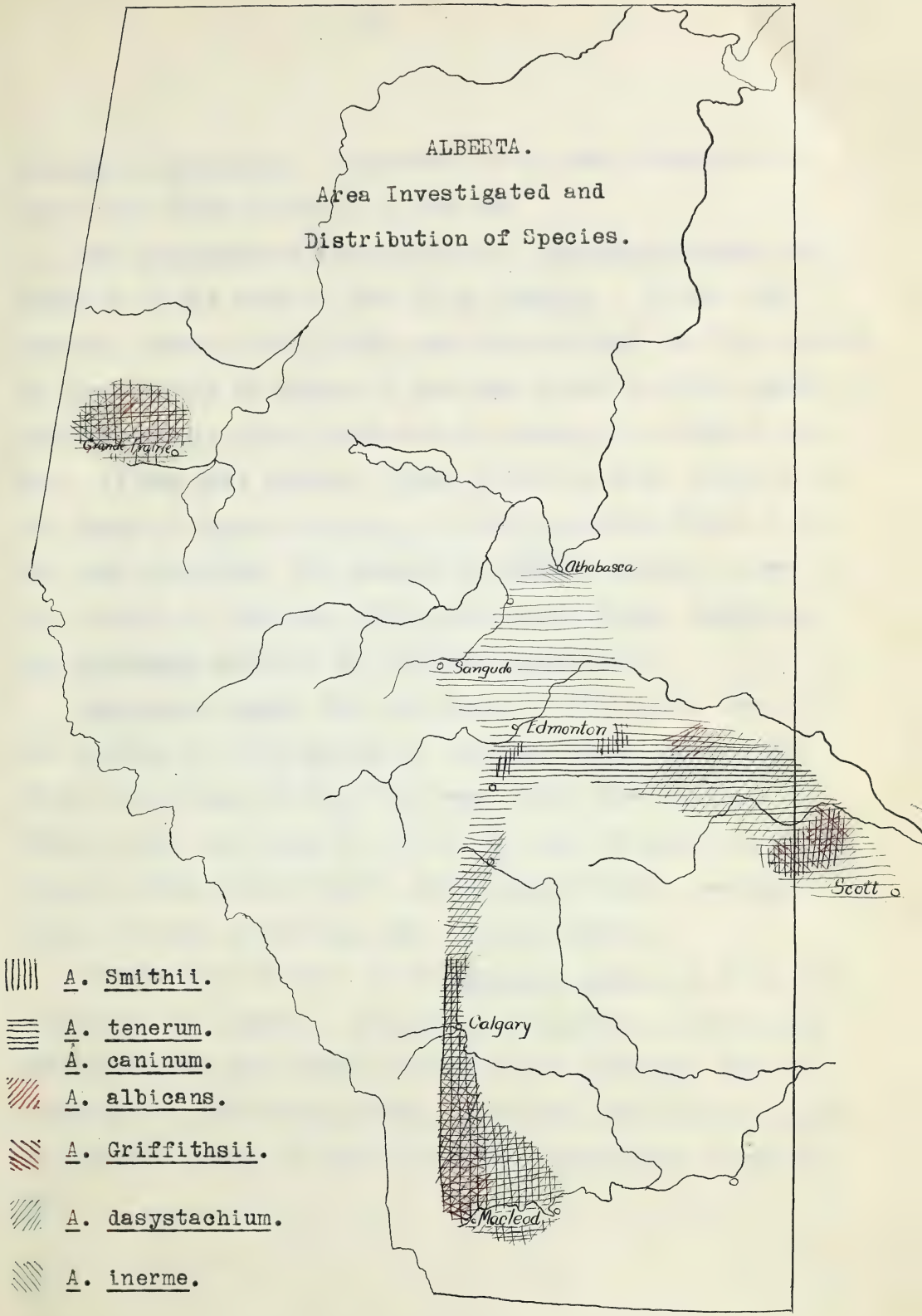
ALBERTA.
Area Investigated and
Distribution of Species.
Grande Prairie
Athabasca
Sangudo
Edmonton
Scott
Calgary
Macleod
A. Smithii.
A. tenerum.
A. caninum.
A. albicans.
A. Griffithsii.
A. dasystachium.
A. inerme.

Figure 1.

grasses to disappear. It appears to be most prevalent in open areas where rainfall is limited.

The geographical distribution of Agropyron caninum was found to be the same as that of A. tenerum . It was not, however, always found in the same associations as that species. In the vicinity of McLeod it was only found in fairly moist regions such as river banks and the edges of irrigation canals. It was most commonly found in fairly moist areas or on the edges of groves; even so, it was frequently found in dry and open locations, for example at Stavely, Alberta it was very common on the open level plain where Stipa, Bouteloua, and Artemesia composed the dominant vegetation.

Agropyron inerme was only found at Athabasca, where it was growing on level ground at the edge of an aspen grove. It has been reported from the Peace river area by E. C. Stacey (13). He found it growing in what is described as the "Upland grass associations", which include"drier meadows, typical upland situations, and exposed places".

Little need be said about Agropyron repens as it is not indigenous to Alberta. It appears to be widely distributed throughout the more moist regions of the province, but was onlyfound on cultivated ground, roadsides, and similar places. It does not appear to have spread to uncultivated ground as yet.

Agropyron Smithii seems to be most widely distributed in dry localities. It was found fairly generally as far north as Edmonton, and is reported as growing in the "upland grass associations" of the Peace river district (Stacey, 13). In the region of Lethbridge and McLeod it appeared to be the dominant grass on land that had once been cultivated but which had been permitted to lie without cultivation for several years. On wild land it was found in areas where Stipa and Bouteloua, or Koeleria cristata and Avena Hookeri were the dominant plants. It was found in several places as an almost pure stand on well drained soil. Farther north it was less common, but present on nearly all open patches of ground in the less wooded parts of the park belt.

Agropyron dasystachium was found quite frequently between McLeod and Didsbury, and from the east of Edmonton from Innisfree to the region around Manitou lake, western Saskatchewan. It was not found in the Edmonton district or north of that city. Specimens were found among the herbarium material collected by E. C. Stacey near Beaverlodge. It appears to be one of the dominant grasses on hilltops in the area classed as long-grass prairie. It was most commonly found associated with Avena hookeri and Koeleria cristata. Almost pure stands were found near Innisfree and in the hills to the north of Manitou lake. These were usually on hilltops or hillsides.

Agropyron albicans was always found associated with A. dasystachium, but not in all localities inhabited by the latter. It was actually found at McLeod, Innisfree, and near Manitou lake. It appears to grow in the driest areas inhabited by A. dasystachium, but was never found as a dominant part of the vegetation.

Agropyron Griffithsii was found on the dry plains and hills near McLeod and north to Okotoks, and on dry hilltops near Manitou lake. It was usually found associated with A. Smithii and A. tenerum, but not as widely distributed as the latter species. Near Okotoks it was found as the dominant grass on a small piece of ground sparsely covered with Symphoricarpos occidentalis Hook.

Agropyron tenerum Vasey.

Data on Plants Propagated from Clones. Forty-eight plants were selected from native habitats in 1926 and transplanted to the University farm. Here they were grown in rows thirty inches apart, the plants being thirty inches apart in the rows. In many cases the transplantation was accompanied by a great change in environment. The transfer, however, did not result in any significant alteration in either the habit or form of any of these plants. Being free from competition and having an ample supply of moisture they grew somewhat larger than they were in nature, but were otherwise unchanged.

[illegible]

[illegible].

latter. It was actually found at [illegible], and

Hamilton lake. It appears to grow in the driest sites [illegible]

held by A. [illegible], but was never found as a dominant

part of the vegetation.

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[illegible].

[illegible].

Data on Plants Transplanted [illegible]. Forty-eight

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[illegible], the plants being [illegible]

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[illegible] a great change in environment. The transfer, however,

was [illegible]

or form of any of these plants. [illegible]

and having an ample supply of moisture [illegible]

larger than they were in nature, [illegible]

Tall upright plants remained tall and upright. Wide-spreading plants retained this habit and in some cases spread even more than before transplantation. Several plants which appeared small and worthless in nature did not materially improve their development in their new habitat. The form of the spikes and awns was not at all affected, though in several cases the plants produced more florets per spikelet. Some of the differences of plant form and habit of growth are illustrated by plates I to IV. The photographs were taken in the autumn of 1927, after the plants had been growing under spaced conditions, and without competition, for two seasons. Plate I shows selection no. 7. It was originally growing in heavy clay-loam soil in an almost pure stand of Symphoricarpos occidentalis Hook., it appeared vigourous and leafy in comparison with other plants of A. tenerum growing nearby. Its vigourous growth in 1927 may be observed from the illustration. In that year it attained a height of 43 inches. Plate II illustrates selection no. 27. It was originally selected as a typical specimen of A. tenerum ; the habit of growth which it represents is one of the most common for the species. Its height was 37 inches when the photograph was taken. A tall erect type of plant is illustrated by plate III. This is selection no. 9 which was originally chosen because it appeared early and very erect. It was taken from poor gravelly soil where Argentina Anserina (L.) Rydb. was

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[illegible] before transplantation. Several plants which appeared
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[illegible]
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[illegible]
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growth which it represents is one of the most [illegible]
species. The height was 37 inches when the [illegible]
taken. A tall erect type of plant is illustrated [illegible]
III. This is selection no. 9 which was originally chosen
because it appeared [illegible] and very erect. It [illegible]
poor gravelly soil where [illegible]

Plate I. Agropyron tenerum.
Selection no. 7. Hgt. 43in.

Plate II. Agropyron tenerum.
Selection no. 27, height 27 ins.

the dominant species. That it retained its original form under cultivation is attested by the photograph. In 1927 its height was 49 inches. Plate IV shows selection no. 50. It was selected because it was low-growing and small. It was originally growing in good black loam on the southerly edge of an aspen grove, it was not heavily shaded or choked by woody plants. In 1927 its longest culm measured 36inches, while the leaf mass was about eight inches above the ground.

It is evident that pronounced differences of form and size existed among these plants. These could scarcely be considered as the result of environmental conditions. The largest plants did not come from the best soil, nor the smallest from the poorest soil; nor was the change of environment found to produce any material change in either habit or morphology. The evidence would seem to indicate that the differences were due to different potentialities in the genetical constitutions of the individuals.

Data on Head-rows Propagated from Individual Plants. In 1926 five selections were made in the strain of Agropyron tenerum known as "Malte's no. 4". These were made from plants that were growing under spaced conditions 36 inches apart both ways. About fifty plants were grown from the seed of each, the progeny being spaced thirty inches apart each way. The plants were well above ground in 1926 and grew to considerable size in 1927. "Malte's no. 4" from which the selections were made is a very uniform and high yielding strain of Agropyron

Plate III. Agropyron tenerum.
Selection no. 9. Hgt. 49 in.

Plate IV. Agropyron tenerum.
Selection no. 50. Hgt. 36 in.

tenerum . Yet among the plants growing under spaced conditions some variation was noticeable, chiefly in height and size of the plants. It was for that reason that the selections were made. No. t. 14.11 was one of the smallest in a lot of two-hundred plants, while t.3.6 was one of the tallest and largest. The other three plants used ranged between these extremes. These plants were all harvested in 1926, being cut off about two inches above the ground. Plates Va, VIa, and VIIa show the development made by three of these plants up to May 20th, 1927. Plates Vb, VIb, and VIIb show the same plants on June 20th of the same year. The differences are very striking.

The progeny of all five plants were, as far as could be determined, exactly alike morphologicaly, but they were not uniform in height. The differences in height are shown in table I, and illustrated graphically by figure 2.

Table I.

Heights of Progenies in Agropyron tenerum.

Line No.	No. of plants.	Mean height. inches.	Mean differences.	Mean differences / Probable error.
t.3.12	48	36.09±0.264	0.0	0.0
t.3.6	46	35.64±0.237	0.35±0.111	3.15
t.11.8	46	35.06±0.222	1.03±0.108	9.53
t.11.13	41	33.37±0.203	2.72±0.104	26.15
t.14.11	46	32.45±0.232	3.54±0.109	32.47

Note; the mean differences represent the difference between the height of each strain and the height of the tallest strain.

Results . Yet among the plants growing much spread out [illegible] ditions some variation was noticeable, [illegible] and size of the [illegible]. [illegible] and the [illegible] tions were made. No. t. 14.11 was one of the smallest [illegible] tallest and largest. The other three plants were [illegible] between these extremes. These plants were all [illegible] 1926, being cut off about two inches above the ground. Plates Va, VIa, and VIIa show the development made by the [illegible] of these plants up to May 20th, 1927. Plates VI, VIb, and VIIb show the same plants on June 30th of the same year. The differences are [illegible].

The progeny of all five plants were, as far as could [illegible], [illegible] uniform in height. The differences in height are shown in table I, and illustrated graphically by figure 3.

TABLE 1.

Results of [illegible]

Line No.	No. of plants.	Mean height. inches.	[illegible]	[illegible]
T.4.11?	48	[illegible]	[illegible]	[illegible]
T.4.?	40	[illegible]	[illegible]	[illegible]
T.14.?	[illegible]	[illegible]	[illegible]	[illegible]
T.14.11	[illegible]	[illegible]	[illegible]	[illegible]
T.?	47	[illegible]	[illegible]	[illegible]

a. May 20th, 1927. b. June 20th, 1927.

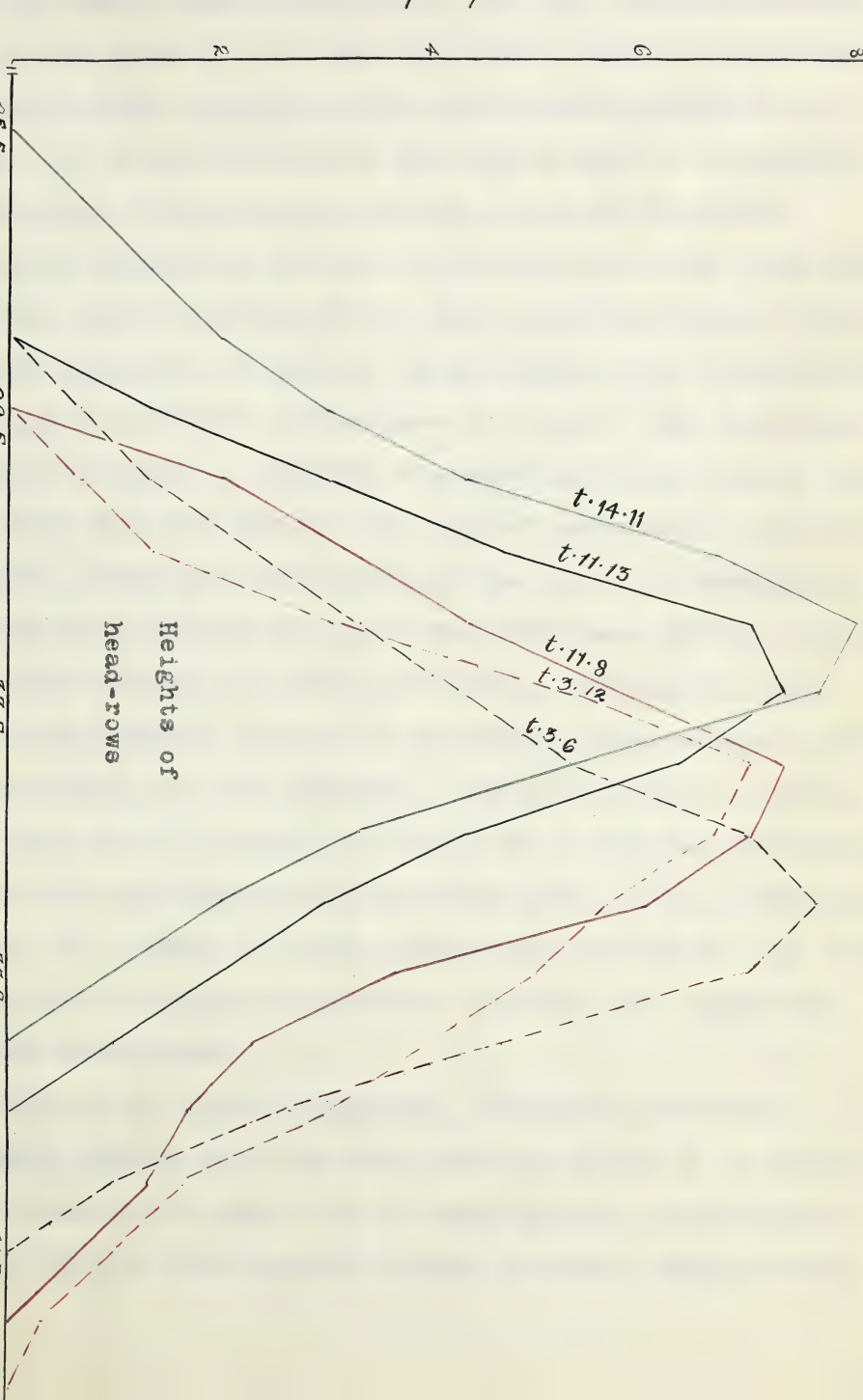
Plate V. Agropyron tenerum.
Selection t.3.6.

a. May 20th, 1927. b. June 20th, 1927.

Plate VI. Agropyron tenerum.
Selection t.11.8.

a. May 20th, 1927. b. June 20th, 1927.

Plate VII. Agropyron tenerum.
Selection t.14.11.



Height in inches.

Table 2.

The plants shown on plates V, Vl, and VII are illustrative of the great differences that exist between individuals as regards their ability to make rapid growth early in the spring. If these differences are stable and not fortuitous fluctuations the evidence seems to point to the desirability of exercising the most rigourous selection in an effort to secure pure varieties of the most desirable types. From the data presented in table I it is evident that these plants possessed significant differences in height. The frequency polygons of figure 2 indicate a general grouping about a central value for each strain, the type of curve being the same for each. When the overlapping of the curves is considered it would be difficult to regard the difference between strain t.3.12 and strain t.3.6 as significant. However, the data point very strongly toward the existence of pronounced differences among the other strains. The odds against a difference being due to chance are 19200.0 to 1 when the difference is six times as large as the probable error of the difference (Jones, 9). Where the mean differences are 6.3 to 16.6 times the probable error one is entitled to regard the difference as being established.

Data on Dr. Malte's strains. Fifty-five strains of Agropyron tenerum that had been selected by Dr. M. O. Malte, and one commercial strain of the same species, were studied at the Dominion Experimental Station at Scott, Saskatchewan

in 1927. Notes were taken on the material in the field and specimens from each plot were later studied in the laboratory. In this, as in other sections of the investigation, attention was centered upon morphological variations and not upon the merits or demerits of any particular strain. Therefore in presenting the data the strain numbers have not been used; each strain considered has been designated by a letter, these letters bearing no relation to the actual plot numbers.

With only a few exceptions these strains were very uniform and showed strong evidence of being pure lines. Most of the differences considered are plot to plot variations. Many differences were found between strains, but some of them did not lend themselves to quantitative treatment. Differences of height and awn length were computed from careful measurements made in the laboratory.

One of the most noticeable characters and one which varied very greatly was the colour of the foliage of the plants. The leaves of some strains were bluish-green in colour and quite glaucous. Other strains were bright green. Between these two extremes lay a wide range of colour types, so that by passing from plot to plot a general gradation from one to the other could be observed. Some plots varied considerably within themselves, but there was more difference between than within strains. There were considerable

in [illegible]. Notes were taken on the material in the field a[illegible]
specimens from each plot were later studied in the labor-
atory. [illegible] in other sections of the investigation
attention was [illegible] upon morphological characters [illegible]
upon the [illegible].
[illegible] in presenting the data the [illegible] numbers have
been used; each strain considered has been designated by
letter, these letters bearing no relation to the actual
numbers.

With only a few exceptions these strains were very
uniform and showed strong evidence of being pure lines.
Many of the differences considered are plot to plot varia-
[illegible]
[illegible]
[illegible]
[illegible].

One of the most [illegible]
varied very greatly was the [illegible]
plants. The leaves of some strains were [illegible]
[illegible]. Other strains were [illegible]
[illegible] a wide range of values [illegible]
[illegible] plot to plot [illegible]
[illegible] observed. Some plots [illegible]
[illegible]
[illegible].

variations in leafiness of the plants in different strains. Actual measurements on a great many individual plants would be necessary to determine how great these differences were. The dried material was found to be quite unsuited to such an investigation, the leaves being shriveled and shrunken. However, no significant difference was found in the number of leaves per plant; therefore differences in leafiness must be due to differences in the length and width of the leaves, or in the lengths of the leaf sheaths. From the green material it was evident that in some strains the proportion of leaf material to total bulk tended to be greater than in other strains. Certain strains had long leaves carried well up the stem, in others the leaves were closer to the ground. The length of the upper leaves appeared to vary a great deal, but sufficient measurements, on green material, were not made to prove to what extent they varied. In habit of growth wide variations were also found, in this respect each strain was generally very uniform. Several strains were found to be very erect in habit, with comparatively thick and strong stems. In other strains the plants were more widely spreading and seemed to have weaker culms. In one strain (designated T) a large proportion of the plants were quite decumbent at the base. This decumbency was not due to growing on the edges of large tufts; there were very few culms per plant in this strain and the decumbent habit was plainly an expression of the natural tendencies of the plants.

The average height of each strain was calculated from measurements on the samples of dried material. As about 100 plants were measured for each plot the average height of the sample should be very close to the average height of the plot. By strains theaverage height ranged from 28.69 inches to 36.50 inches. Table II shows the average heights of five strains chosen to illustrate the differences. Where the difference between two strains is more than three times the probable error of the difference one is justified in regarding the difference as significant (Jones, 9 and Hayes and Garber, 6). Figure 3 gives a graphical comparision of these five strains.

Table II.

Mean heights of five strains of Agropyron tenerum.

Line No.	No. of plants.	Mean height. inches.	Mean differences.	Mean differences / PRObable error.
Q.	106	36.51±0.206	0.0	0.0
O.	105	35.25±0.182	1.26±0.275	4.85
G.	84	32.84±0.180	3.67±0.274	13,39
S.	98	30.36±0.197	6.15±0.285	21.57
M.	87	28.69±0.144	7.82±0.251	31.15

Note; the mean differences are the differences between each strain and strain Q.

The length of awn for each strain was computed from measurements made on about one-hundred plants of each. The measurements were made on the second floret of the fourth spikelet for each spike. Where the awn was less than 1 mm. long its length was not accurately determined, such plants were classed simply as having awns less than 1 mm. long. Three conditions of awn length were found to exist viz, strains having awns less than 1 mm. long, strains with awns between 1mm. and 2 mm. long, and certain plants with awns several mm. long. Data on four strains are presented in table III to show the differences in awn length existing among these strains. The data are shown graphically in figure 4. Table III and figure 4 are quite representative of relative awn lengths for the fifty-five strains.

Table III.

Awn lengths in Agropyron tenerum.

Strain designation.	No. of plants.	Mean length of awn. mm.	Mean differences. mm.
D.	100	1.65±0.027	0.0
F.	100	1.28±0.023	0.37
K.	102	0.81±0.0028	0.84
I.	104	All less than 1 mm.	more than 0.65 mm.

Note; the mean differences represent the difference between each strain and strain D. The probable error of the mean of strain I could not be calculated as the lemmas were almost awnless. The meam and probable error for strain K. are only approximate.

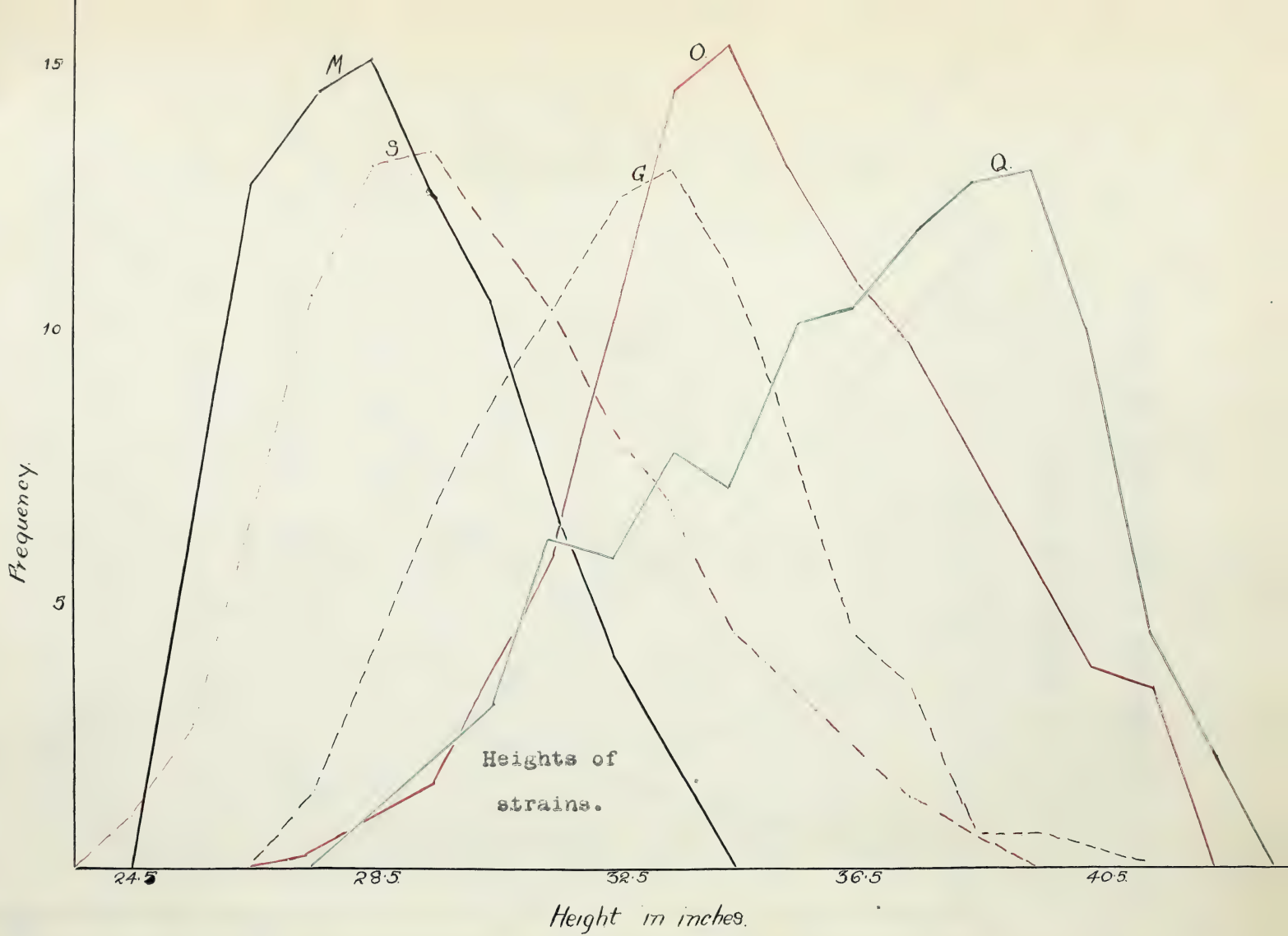

15
10
5
Frequency.
M
S
G
O
Q.
Heights of
strains.
24·5
28·5
32·5
36·5
40·5
Height in inches.

Figure 3.

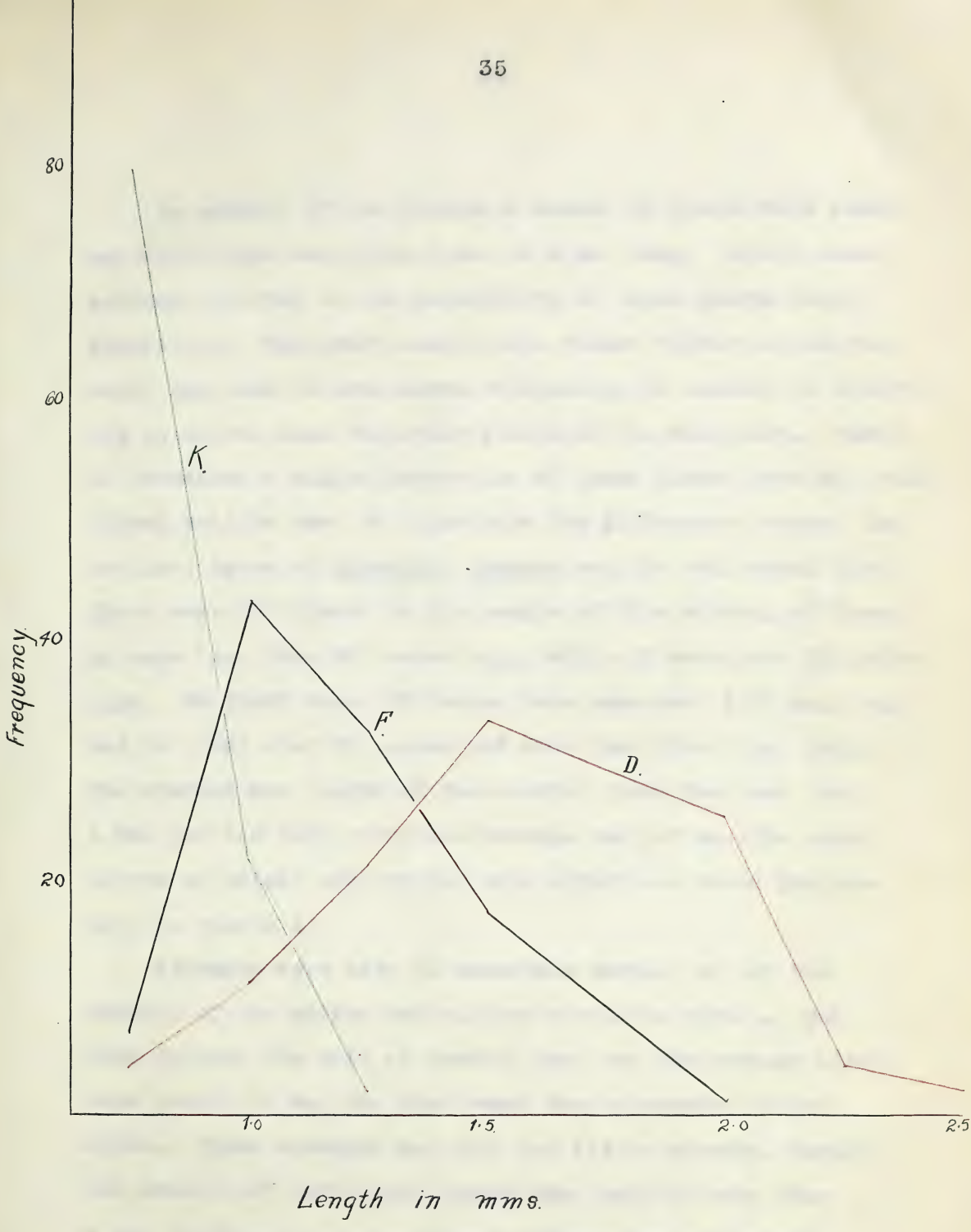


Figure 4. Awn lengths of strains.

In several of the strains a number of plants were observed which bore awns from 2 mm. to 5 mm. long. In all cases evidence pointed to the possibility of these plants being impurities. They were mostly tall rather vigourous individuals, and were in some cases outstanding on account of differing in colour from the other plants of the same plot. Strain A. contained a higher proportion of these plants than any other. It may well be used to illustrate the difference between the ordinary types of Agropyron tenerum and the tall awned type. There were 100 plants in the sample of this strain; of these 85 were less than 38 inches high, while 15 were over 38 inches high. No plant under 38 inches bore awns over 1.25 mm. long, and no plant over 38 inches had awns less than 2 mm. long. The average awn length of the shorter group was less than 1 mm. for the tall group the average was 3.7 mm. The characters of height and awn for this strain are shown graphically in figure 5.

Attempts were made to ascertain whether or not the density of the spikes varied from strain to strain. For this purpose the unit of density used was the average internode length in mm. for the lowest ten internodes of the spike. These attempts met with but little success. Though the density of individual spikes was found to vary from 7 mm. to 15 mm., no significant differences were found between strains.

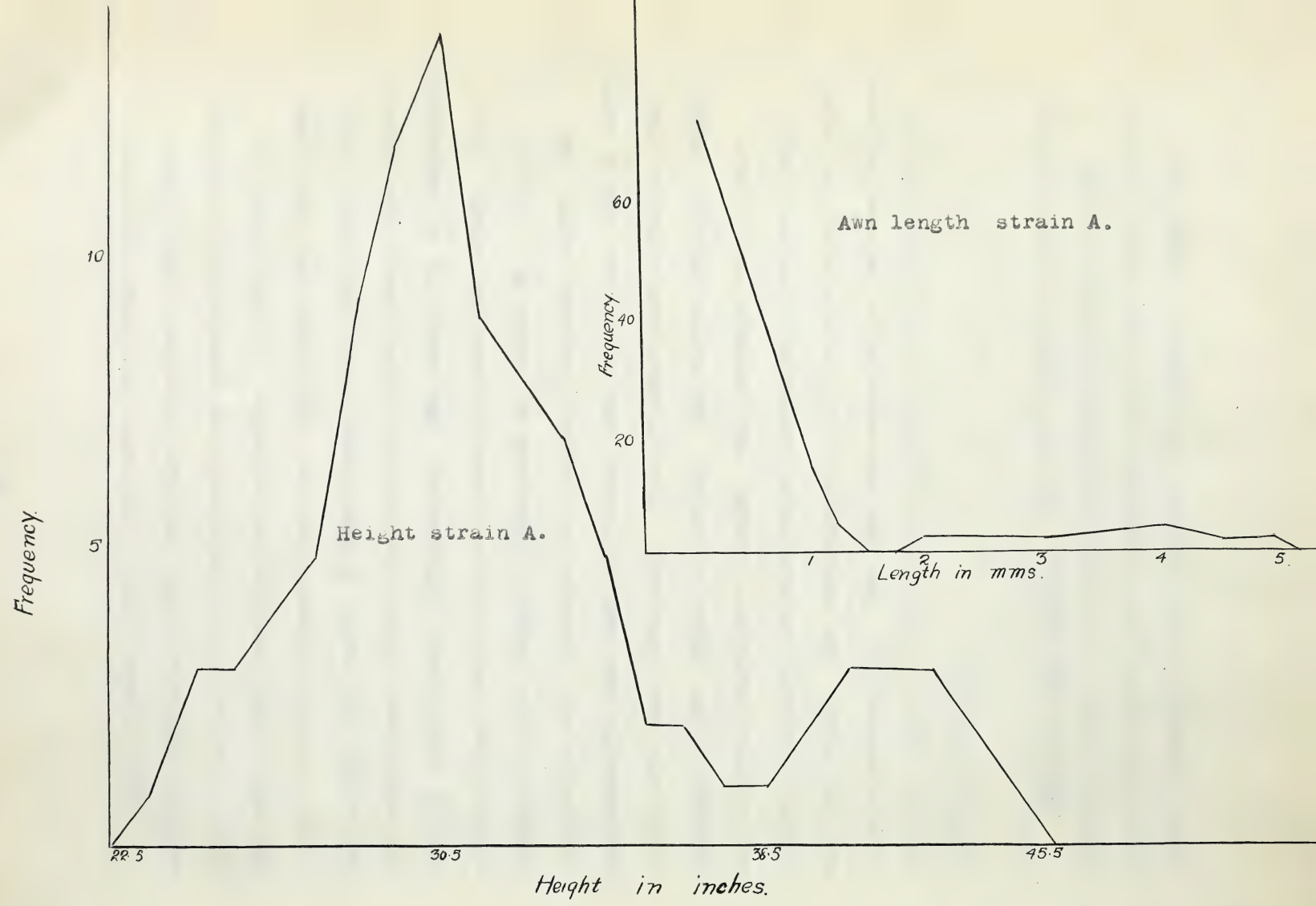

Frequency.
10
5
Height strain A.
22.5
30.5
38.5
45.5
Height in inches.
Awn length strain A.
Frequency
60
40
20
1
2
3
4
5
Length in mms.

Figure 5.

Table II and figure 3 indicate that height is a very variable character, but they also show that within these strains the height of the plants was comparatively uniform. The data on awn length given on table III and plotted on figure 4 do not possess the same significance as that given for height, the units of measurement being very small. Yet, the consistency within the strains points towards the existence of significant differences. The stability of characters of this type could only be proven by genetical study. The polygon for the length of the awns of strain K. (fig. 4) appears to be a fraction of a normal frequency curve. Had measurements been made of values less than 1 mm. such a curve might have been obtained. It is evident that strain A. was composed of two types of plants. The curves both for height and for awn length are bimodal, and inasmuch as the same plants fell into the same modal groups, both for awn length and for height, the heterogeneity of the strain may be regarded as a certainty. The absolute association between tallness and awn length in this strain points to the possibility of genetic coupling.

Data on Wild Plants. All the variations found on cultivated plants, or on wild plants that had been brought under cultivation, and discussed above, were found on wild plants growing in various parts of Alberta. Plate VIII

Table IV and figure 4 indicate that height is a ver[y]
variable character, but they also show that within these
strains the height of the plants was comparatively unifo[rm].
The data on awn length given on table III and plotted on
figure 4 do not possess the same significance as that gi[ven]
for height, the units of measurement being very small. [illegible]
the consistency within the strains points towards the ex[ist-]
ence of significant differences. The existence of genes
of this type could only be proven by genetical study. [illegible]
polygon for the length of the awns of strain [illegible]
appears to be a fraction of a normal frequency curve, [illegible]
measurements been made of below less than 1mm, [illegible]
might have been obtained. It is evident that strain [illegible]
composed of two types of plants. The curves both for he[ight]
and for awn length are bimodal, and inasmuch as the same
plants fall into the same modal groups, both for awn length
and for height, the heterozygosity of the strain may be re[gard-]
ed as a certainty. The absolute association between tal[l]
and awn length in this strain points to the possibility [of]
genetic coupling.

Data on wild plants: All the varieties found on [illegible]
growing wild, or on wild plants that had been [illegible]
under cultivation, [illegible], were found [illegible]
[illegible]

shows the various types of spikes found. Though very similar they show a considerable range of density, variations in awn length can also be observed. Representative florets from these spikes are shown on plate IX, the wide range of awn length is clearly shown; the longest awn being 6.5 mm. long. No evidence was found to indicate that morphological characters are to any extent affected by environmental conditions, except as mentioned below. Plants growing in dry habitats, or under conditions of severe competition, were found to be smaller and less vigourous than those growing under more favourable conditions. There was also found to be a wide variation in the number of florets per spikelet. Vigourous plants growing in good soil were sometimes found to have as many as twelve florets per spikelet, while less favoured individuals bore only three or four. In 1927 a large number of plants were observed with brachytic spikes, many others had paired spikelets. These variations were never found to be constant for a whole plant and were regarded simply as abnormalities. An individual plant found near Ribstone, Alberta, is of special interest. It is the only specimen of Agropyron tenerum with pubescent leaf-sheaths which has been observed by the writer. The word pubescent is used here because it is a common term, it is believed that the leaf-sheaths of this plant are better described as setulose. The setae were comparatively short and arose

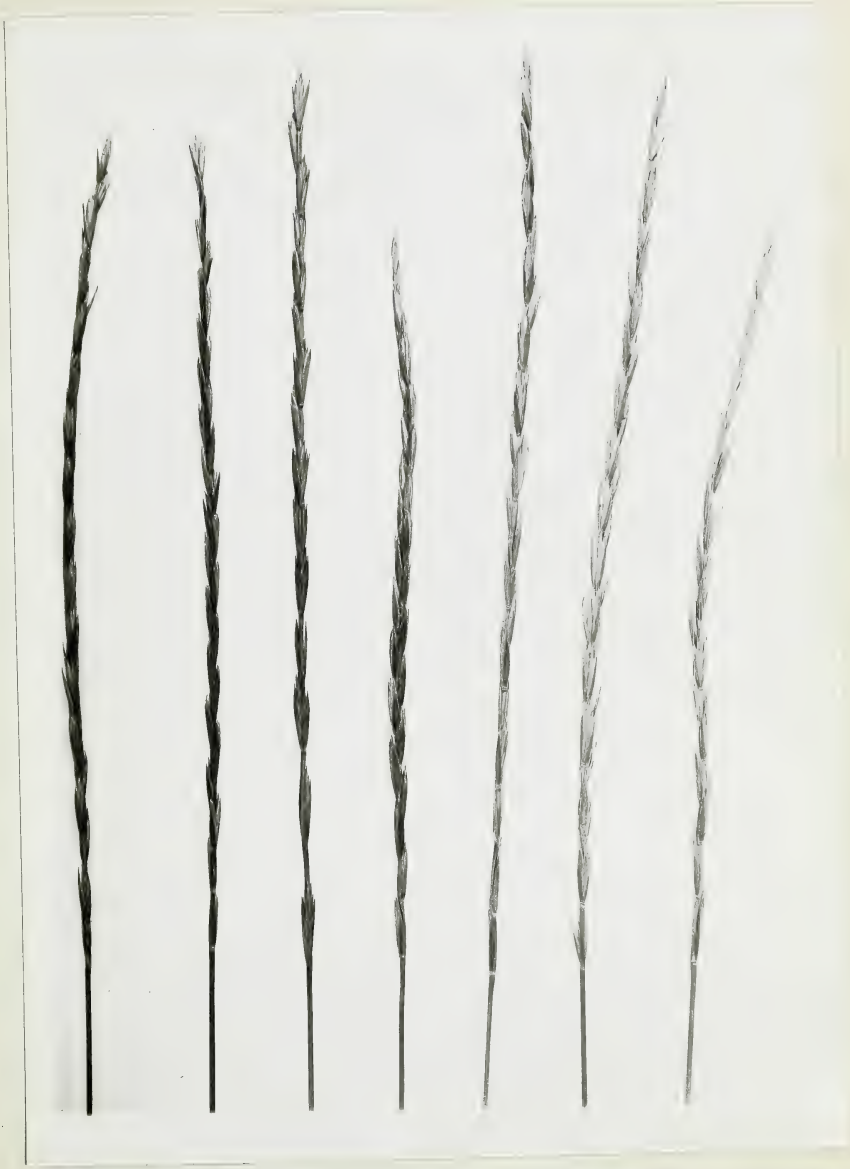


Plate VIII. Types of spikes of Agropyron tenerum.

Plate IX. Types of florets of Agropyron tenerum.

principally along the nerves of the sheaths and the upper surfaces of the leaf-blades. They were most prominent along the edges of the lower sheaths.

Agropyron caninum (L.) Beauv.

Ten plants of Agropyron caninum which were growing wild in the Edmonton district were transplanted to the University farm in 1926. They were treated in exactly the same manner as the plants of A. tenerum previously described. There were no special reasons for making these selections except that the awns appeared to vary considerably in length. All were erect vigourous plants with unilateral spikes. After they had been growing in the field for two seasons the only differences observable were slight variations in height and considerable variations in awn length. The length of awns of the mature plants ranged, in 1927, from 5 mm. to 32 mm. Specimens 2 to 8 inclusive, plate X are spikes from seven of these plants. Representative florets from the same spikes are shown on plate XI nos. 2 to 8 inclusive.

In October 1926 the writer observed a plant growing on the open prairie at Marsden Saskatchewan. It was densely tufted and erect in habit of growth, with many sterile shoots and a few seed-bearing culms. The lemmas bore awns about 15 mm. long and the spike showed no evidence of being unilateral. In fact it was originally thought to be Agropyron tenerum.

Plate X. Spikes of Agropyron inerme and Agropyron caninum.

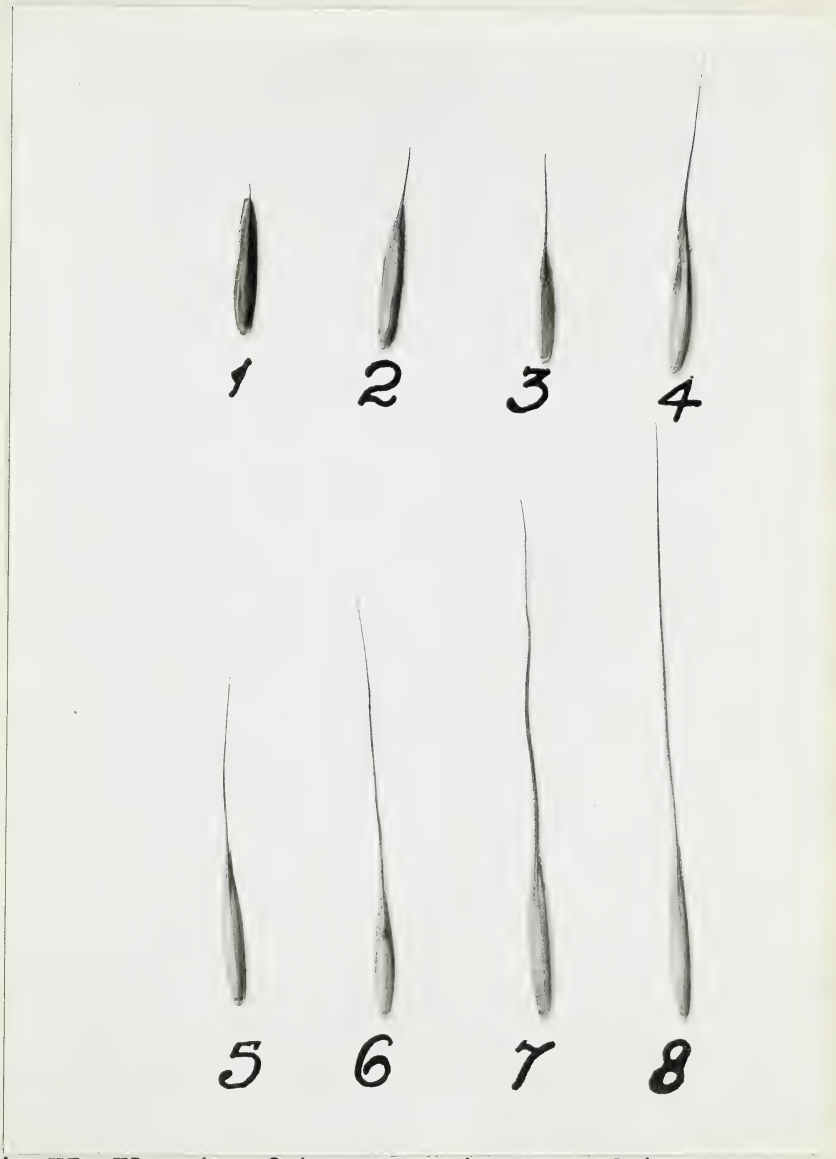


Plate XI. Florets of Agropyron inerme and Agropyron caninum.

After the heads had dried they appeared somewhat unilateral. One of the spikes was found to contain mature seeds, so a few of them were removed and planted in the greenhouse. The seedlings attained considerable growth during the winter of 1926 to 1927; they were transplanted to the field in the spring of 1927. The plants which developed in the summer of 1927 were low and quite procumbent. The spikes, however, were large and coarse with pronounced unilaterial tendencies. One of these plants is shown on plate XII. The spikes and seeds of parent and progeny are compared on plate XIII. The differences are evident. The difference between parent and progeny was probably due to the changed environment. It is conceivable that the parent plant might have been heterozygous, from evidence presented in Part II such a possibility is quite remote.

The spikelets of Agropyron caninum were found to be closely appressed to the rachis, sub-terete, with four to eight florets; the glumes not as long as the spikelet, five nerved, broadest at or above the middle, terminated by an awn or an awn point; the lemmas boat shaped, Acuminate with a long awn; the paleas usually as long or slightly shorter than the lemmas, the apex blunt, minute hairs on the edges and tip could be seem with a microscope.

From field observations and notes on specimens collected in various parts of Alberta and Saskatchewan, it appears

[illegible]

were large and coarse with pronounced unilateral tende-

[illegible]

seeds of parent and progeny are compared on plate XIII.

differences are evident. The difference between parent

progeny was probably due to the changed environment. [illegible]

[illegible]

The evidence on Agropyron [illegible] [illegible]

[illegible]

[illegible] florets; the glumes not as long as the spikelet,

five nerved, broadest at or above the middle, terminated

[illegible]

Plate XII. Agropyron caninum
Selection no. 50.

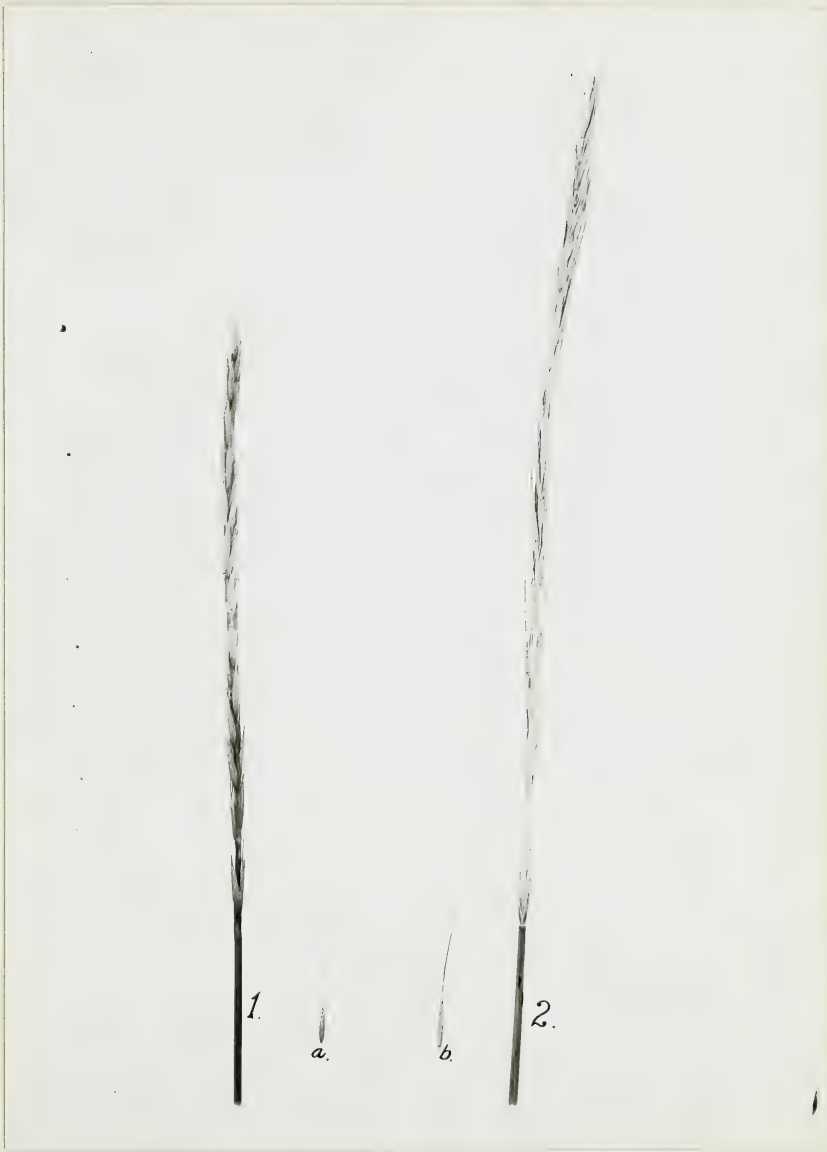


Plate XIII. Agropyron caninum.

Selection no. 50.

1. Parent, a. floret.

2. progeny, b. floret.

that Agropyron caninum grows most commonly in semi-shaded or moist locations. In such habitats it is usually tall and vigourous with long, coarse, long-awned spikes. It is not, however, by any means limited to such habitats. It was observed growing in many cases on open prairie, dry hillsides, and even hilltops. Under the conditions just described it is usually less vigourous in growth with shorter more compact spikes, and with shorter awns, than when growing in moist areas. Even so, specimens comparable in every respect with those shown on plate X were collected in the Tawattinaw valley between Athabasca and Clyde, Alberta. The land in this valley is quite low-lying, while the grass-covered areas are only small openings in the timber. The data seem to indicate that significant differences of awn length exist, and that the long-awned types do not develop in dry regions on account of the inhibitions of the environment.

Agropyron inerme (Scribn. and Smith) Rydb.

Seeds of Agropyron inerme were planted in the greenhouse in the autumn of 1926. These had been provided by Mr. E. C. Stacey and were taken from a specimen that had been identified by Dr. A. S. Hitchcock. The plants which developed from these seeds were transplanted to the open in the spring of 1927, and grew to considerable size during the summer of that year. The mature plants were fairly erect, tufted,

and about 30 inches high. Sterile shoots were produced, but most of the culms developed inflorescences. The stems were coarse and strong; leaves comparatively long and broad, blades scabrous both above and below, the sheaths were smooth, the auricles pronounced and clawlike; spikes exserted, long, lax, and distinctly unilateral; spikelets closely appressed to the rachis, sub-terete, with six to ten florets; glumes about one half as long as the spikelet, five-nerved, broadest at or above the middle, 10 mm. to 13 mm. long, terminated by an awn point; lemmas boat-shaped, accuminate with an awn-like bristle about 1.5 mm. long, 10 mm. to 12 mm. long; paleas usually slightly longer than the lemmas, the apex blunt, minute silvery hairs on the edged and tip could be observed with a microscope.

The wild plants collected did not differ from this description in any respect. A typical spike of this species is shown on plate X no. 1; a floret on plate XI no.1. The blunt tip of the floret on plate XI is due to the palea protruding beyond the lemma, the latter is acuminate.

Comparison of Agropyron caninum and A. inerme. A comparision of the descriptions of Agropyron caninum and A. inerme indicate a striking similarity between the two species. The only differences that were found between the plants of each were the long awns of A. caninum, and the slightly longer

paleas of A. inerme. From plates X and XI a gradation from A. inerme to the longest-awned types of A. caninum may be observed. These findings point to the possibility of the two spesies being in reality but one. To prove whether or not this is the case further investigation is needed. If they possess the same chromosome numbers and produce fertile hybrids when crossed, one would be justified in classing them as a single species.

Agropyron Smithii Rydb.

Though found growing in many section of Alberta no widely variant types of Agropyron Smithii were found. The plants examined were stoloniferous with creeping horizontal rootstocks, loosely tufted, with many sterile shoots; the whole plants bluish-green in colour, often glaucous, usually 18 to 30 inches high; leaf-blades long and fine, often involute, scabrous below; spikes dense, about 10 cm. long, the spikelets overlapping, often in pairs; spikelets not closely appressed to the rachis, six to twelve flowered; glumes usually less than half the length of the spikelet, widest below the middle, keeled; lemmas about 10mm. long, usually acuminate, sometimes awn-pointed. Several plants were found with a few downy hairs on the lemmas, but it could scarcely be said that they were pubescent. A typical plant of A. Smithii is shown on plate XIV, a spike on plate XVII no.4, and a floret on plate XVI no. 6.

Plate XIV. Agropyron Smithii.

A typical plant.

Agropyron repens (L.) Beauv.

Agropyron repens was found growing as a weed in various parts of Alberta. The plant is characterized by its vigourous growth and long creeping rootstocks. Two types of plant were found. The more common form was bright green in colour; the spikes long, lax and erect; the spikelets somewhat flattened, standing out from the rachis at an angle of about 25 degrees, usually six to ten flowered; the glumes somewhat shorter than the spikelets, slightly unequal, about 10 mm. long, acute to accuminate or with a short awn point. The second form, which appears to be less widely distributed than the first but is very prevalent in the Edmonton district, differs but slightly from the first. In colour it was bluish-green, having a distinct bloom on the stems and leaves; the glumes terminate in an awn about 4 mm.long; the lemmas bear awns 4 mm. to 7 mm. long. Otherwise the two types were identical. Type I is shown on plate XV no. 2, type II on the same plate no. 3. The florets of these types are shown on plate XVI nos. 10 and 11.

Agropyron dasystachium (hook.) Scribn.

Plants of Agropyron dasystachium were collected in various localities, always on open ground and usually in comparatively dry well-drained soil. In general appearance

the plants were very similar to A. Smithii, with which species they were often associated. Typical plants were loosely tufted from creeping rootstocks; the stems erect, usually glaucous and a silvery-green colour; spike compact, six to ten mm. long, not quite as dense as A. Smithii; spikelets sub-terete, four to ten flowered; glumes usually about one half the length of the spikelet, lanceolate, sometimes awn pointed, smooth and glabrous, sparingly pubescent, densely pubescent, or long-villous, usually about 7 mm. long; lemmas lanceolate to acuminate, sometimes with an awn point or an awn 1.5 mm. to 4 mm.long, sparingly pubsecent, densely pubescent, or long-villous. Two general conditions were found to exist in the relation of awn length to the degree of pubescence. Type I; glumes glabrous to pubescent, awns 1.5 mm. to 4 mm. long. Type II; glumes long-villous; lemmas long-villous, awn pointed. Three typical spikes are shown on plate XVII nos. 1 to 3, Five florets showing the range of pubescence and awn length are shown on plate XVI nos. 1 to 5.

Agropyron albicans Scribn. and Smith.

Agropyron albicans was only found in two places in Alberta, and one in Saskatchewan; only a few scattered plants were found at each point. These plants were erect in habit of growth, loosely tufted from creeping rootstocks, 20 to 30 inches high, light green in colour; stems fine; leaves short,

the plants were very similar to A. *Smithii*, with which u

[illegible]

ed from creeping rootstocks; the stem erect, [illegible]

and a silvery-green color; spike compact, [illegible] to ten

not quite as dense as A. *Smithii*; spikelets [illegible],

ten flowered; glumes usually about one half the length o

spikelet, lanceolate, sometimes awn pointed, smooth and

[illegible]

[illegible]

sometimes with an awn point or an awn 1.5 mm. to 4 mm. lo

[illegible]

two general conditions were found to exist in the relati

of awn length to the degree of pubescence. Type I: glume

glabrous to pubescent, awns 1.5 mm. to 4 mm. long. Type

glumes long-villous; lemmas long-villous, awn pointed.

Three typical spikes are shown on plate XVII nos. 1 to 3,

five florets showing the range of pubescence and awn leng

are shown on plate XVI nos. 1 to 5.

Agropyron albicans Scribn. and Smith.

Agropyron albicans was only found in two places in

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were found at each point. These plants were erect in h

of growth, loosely tufted from creeping rootstocks, [illegible]

inches high, light green in color; [illegible]

Plate XV. Spikes of Agropyron.

1. A. crystatum. 3. A. repens.

2. A. repens. 4. A. pungens.

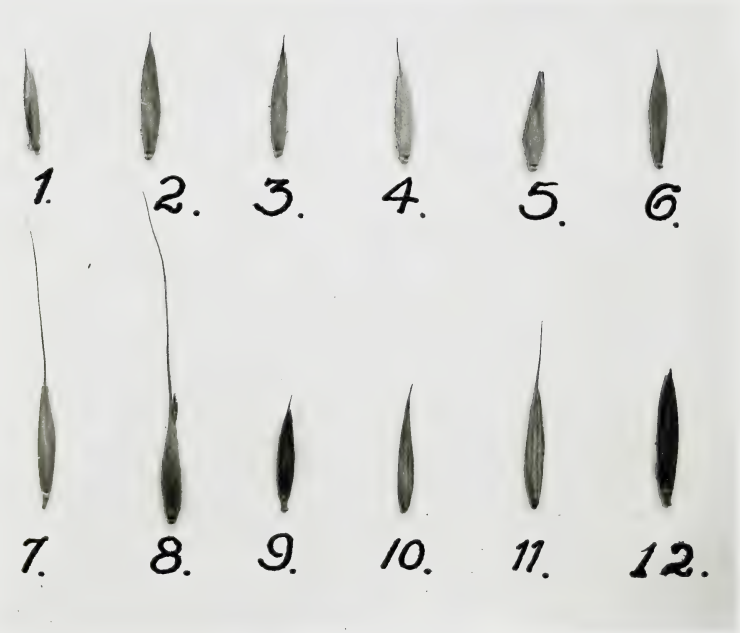

Plate XVI. Florets of Agropyron spp.

1-5. A. dasystachium.
6. A. Smithii.
7. A. Griffithsii.
8. A. albicans.
9. A. crystatum.
10-11. A. repens.
12. A. pungens.

Plate XVII. Spikes of Agropyron spp.

1-3. A. dasystachium. 5. A. Griffithsii.

4. A. Smithii. 6. A. albicans.

narrow, and few in number; spikes 10 mm. to 12 mm. long, fairly compact; spikelets four to six flowered, sub-terete; glumes oblanceolate, with an awn 2 mm. to 4 mm. long, short pubescent; lemmas boat shaped, awn 10 mm. to 15 mm. long, short pubescent. The awns of both the lemmas and the glumes were divergent. A typical spike is shown on plate XVII no.6, a floret on plate XVI no. 8.

Agropyron Griffithsii Scribn. and Smith.

Agropyron Griffithsii was found to be more widely distributed than A. albicans. Its prevalence was not, however, comparable to that of A. dasystachium or A. Smithii. The plants of this species were somewhat taller and coarser than those of A. albicans, otherwise the only difference between them lay in the pubescent glumes and lemmas of the latter. The lemmas and glumes of A. Griffithsii were merely scabrous. A spike of this species is shown on plate XVII no.5, a floret on plate XVI no. 7.

The great similarity of Agropyron albicans and A. Griffithii, coupled with the limited evidence of differences, indicates the possibility of the two being one and the same species.

Agropyron pungens (Pers.) R. and S.

The only plants of Agropyron pungens observed were those grown at the University of Alberta from seed supplied by Suttons, Reading, England. These plants were vigourously creeping, the rootstocks being long and stout. The culms were erect, stiff, about 40 inches high; the stems coarse and almost entirely filled with pith; the leaf-blades long, wide, and strongly nerved, smooth below, scabrous above, auricles present and claw-like; spike erect, compact, the spikelets overlapping; the spikelets long, flat, appressed, eight to twelve flowered; glumes about one half as long as the spikelte, scabrous, distinctly keeled, acute ; lemmas scabrous, keeled, acute. A typical spike is shown on plate XV no. 4; a floret on plate XVI no. 12.

Agropyron crystatum------

Agropyron crystatum was introduced to the University of Alberta from Mandan, N. D. in 1923. It is said to be native in the region of the Ural mountains and is called "Ghitnick" in Russia. The plants studied were being grown on the University plots in 1926. These plants were erect, densely tufted, about 36 inches high; the stems fine, rather brittle and harsh; the leaf-blades long and fairly wide, shorter at the top than at the base of the stem; the spikes very dense, erect to nodding; spikelets flat, standind out from the rachis

at an angle of about 45 degrees, five to fifteen flowered; glumes shorter than the lemmas, much shorter than the spikelets, distinctly keeled, rough only on the edges, broadest below the middle, accuminate with a minute awn point; lemmas similar to the glumes but slightly longer, more acute, with an awn about 2mm. long. A plant is shown on plate XVIII, a spike on plate XV,no.1, a floret on plate XVI no.9.

Concluding Remarks.

Gray (4) states that Agropyron dasystachium (Hook.) Scribn. closely resembles A. repens (L.) Beauv. The plants of these two species found growing in Alberta did not resemble each other in any respect. A. repens was found to be a tall plant with long thick rhizomes and a long lax spike. A. dasystachium was observed to be comparatively low-growing with short fine rhizomes and a short dense spike.

In general appearance Agropyron Smithii, A. dasystachium, A. albicans, and A. Griffithsii were found to be very similar. They were usually light green in colour and generally glaucous, all fairly short plants with short, thin rhizomes. A.Smithii could always be distinguished from A. dasystachium by the acuminate character of its glumes, A. dasystachium having having lanceolate glumes. A. albicans and A. Griffithsii were always recognized by their long divergent awns, and distinguised from each other by the pubescent glumes and lemmas of A. albicans.

at an angle of about 45 degrees, five to fifteen flow[illegible]
glumes shorter than the lemma, much shorter than the [illegible]
[illegible]
below the middle, conduplicate with a minute awn point; le[illegible]
similar to the glumes but slightly longer, more acute, [illegible]
an awn about 2mm. long. A plant is shown on plate [illegible]
a spike on plate XV, no.1, a floret on plate XVI no.1.

[illegible]

[illegible] Agropyron dasystachyum (Hook.)
Vasey. closely resembles A. repens (L.) Beauv. The plan[illegible]
of these two species found growing in Alberta did not re[illegible]
ble each other in any respect. A. repens was found to [illegible]
[illegible]
A. [illegible] was observed to be comparatively [illegible]
with short fine rhizomes and a more dense crown.

In general appearance Agropyron Smithii, A. dasystach[illegible]
[illegible], and A. Griffithsii were found to be very sim[illegible]
[illegible]
all fairly erect plants with a short, thin rhizome. A. [illegible]
could always be distinguished from A. [illegible]
acuminate character of its glumes. [illegible]
[illegible]

Plate XVIII. Agropyron crystatum.

A typical plant.

Part II.

Mode of Pollination in five Species of *Agropyron*.

INTRODUCTION.

A knowlege of the mode of fertilization of the crop in question is essential before the plant breeder can hope to do successful work. This is true because different methods must be employed when breeding plants with different modes of pollination. And further, plants which are normally self-fertilized are very likely to possess a high degree of genetic homozygosity, while plants which are naturally cross-fertilized are just as likely to be heterozygous.

According to Hayes and Garber (6) all sexually reproducing seed bearing plants may be placed in three groups according to their natural habits of pollination. These groups will in some cases overlap on account of environmental differences and inherent factors.

Group 1. Plants naturally self-pollinated; eg. *Triticum aestivum*, *Avena sativa*, *Hordeum vulgare*.

Group 2. Plants often cross-pollinated; eg. *Zea mays*, *Secale cereale*, *Medicago* spp. many grasses.

Group 3. Plants always cross-pollinated in nature; eg. *Trifolium pratense*, *Helianthus annuus*, *Bulbilis dactyloides*.

In perfect flowers the mechanics of the essential parts have a profound effect on the mode of pollination. Dioecious species need no consideration, self-pollination is impossible for them. Monoecious species may be self-fertilized if the pollen is ripe at the same time that the stigmas are receptive.

Among hermaphroditic plants several devises are employed to increase or inhibit natural cross-pollination. In wheat, oats, and barley the stigmas are receptive at the time that the pollen is ripe; as the flowers open the anthers dehisce, dropping pollen onto the stigmas. In rye, on the other hand, the anthers are placed below the stigmas and dehisce in such a way that their pollen cannot reach the stigmas of the same flower. There is also some evidence (6) to show that rye is self sterile to a high degree. Plants may be naturally cross-fertilized because they mature their pollen at a time when the stigmas are not receptive. In other cases, as for example the sunflower, the female elements may be self-sterile.

Review.

The study of the habits of pollination presented a complex problem. It was necessary to devise a scheme by which the natural habits of the species under consideration would be shown.

A cursory examination of the plants at flowering-time shows that the pollen is ripe and that the anthers dehisce at a time when the stigmas are receptive. In the five species studied the anthers were always found above the stigmas. Flowering may easily be observed on a bright afternoon, and if the peduncle of the spike is held in the hand the extra heat (apparently) will increase the rate of flowering. As an individual flower opens one first observes the palea to move out slightly from the lemma, the stigmas then unfold and are thrown out into the air through the space between the lemma and the palea. At the moment that the stigmas are thrown out the anther filaments are extended, the anthers protrude from between the flowering bracts and dehisce. In Agropyron tenerum one anther has often been found empty before the flower opened. These observations would appear to indicate every opportunity for natural self-pollination. But investigation would be necessary before conclusions could be drawn.

The only previous work reported was that done at the University of Minnesota on Agropyron tenerum (6). Here the difference between the percentage of seed set when isolated and when free-flowering was considered as indicative of the extent of cross-polination. This does not seem to be sufficient proof. There is no reason, outside of self-sterility, protandry, or protogyny, why a plant which is normally cross-pollinated to a high degree cannot be self-pollinated when

foreign pollen is excluded.

If the plants under consideration are to any extent cross-pollinated it would be reasonable to expect that when they are emasculated and left exposed to wind-blow pollen they would set about as much seed as would naturally be the result of cross-pollination. Even so, the fact that an emasculated plant sets seed is not proof that it is to any extent cross-pollinated in nature. When the flowers of Agropyron open the anthers dehisce at the same moment that the stigmas are thrown out. In some cases the anthers have been found to dehisce before the flowers opened. But, even though the stigmas are covered with pollen from the same flower they are thrown out into the air. It seems very possible, therefore, that when a flower, naturally self-pollinated, is deprived of its own pollen it might still be fertilized by foreign pollen. If one species consistently sets more seed than another when the flowers are emasculated one is justfied in assuming that that particular species has a greater natural adaptation towards cross-pollination than the other species, and that probably the omount of seed set under such conditions is proportional to the amount of natural cross-pollination.

INVESTIGATION.

Materials.

For the investigation of Agropyron tenerum, A. Smithii, and A. crystatum pure cultures growing on the University farm were utilized. The plants of A. repens and A. caninum which were studied were growing as almost pure stands on waste ground near the University. They were all normal and vigourously growing plants.

Methods.

Within each species the plants of Agropyron are very similar, and no cases of xenia are known to exist. Therefore, to obtain actual proof of cross-fertilization it would be necessary to grow the progeny of a single plant for at least two years in order that segregation might be observed. To secure statistically safe results by this method would require a large expeniture of time and money, it was therefore ruled out as impracticable. The scheme described below appeared to be quite feasible and so was adopted.

Some time before the pollen grains were ripe 300 florets of each of five species were emasculated, 200 of these were left exposed to wind-blown pollen, and 100 were protected by waxed paper covers. Of the latter 50 were hand pollinated with pollen of the same species, while 50 were left without

pollen for use as a check on the effectiveness of emasculation. At the same time heads on several plants of each species were bagged without emasculation, these were to measure the ability of the plants to set seed without being exposed to wind-blown pollen. The exact number of florets on each head used in this investigation was known and records were kept of the exact number of seeds set on each. This work was carried on during the summers of 1926 and 1927.

Description.

Five species of Agropyron were studied in this investigation, as follows, A. tenerum, A. Smithii, A. crystatum, A. repens, and A. caninum. Plants on the edges of the plots were not used. The following procedure was carried out for each species.

1. A number of spikes on different plants were chosen, all but about six spikelets were removed as were also the terminal florets of each spikelet. The remaining florets were then counted and the number recorded on the labels. The spikes were then bagged and after two or three weeks the seeds were counted , the number being recorded on the original label as well as in the field notes.

2. The treatment was as in the foregoing section except that the flowers were all emasculated and left exposed to wind-blown pollen.
3. Spikes treated in the same manner were emasculated and bagged. They were carefully observed and when the stigmas were mature foriegn pollen of the same species was introduced. The bags were then replaced and the seeds counted as under section 1.
4. The plants were treated as in section 3. except that no foriegn pollen was introduced.

FINDINGS.

Data.

The results of these experiments are set forth below. The raw data are presented in tables, the reason for which will become apparent later. Table IV shows the amount of seed set when the spikes were bagged, that is, when foriegn pollen was excluded. Table V shows the amount of seed set when the florets were emasculated and exposed to wind-blown pollen. Table VI shows the amount of seed set when the florets were emasculated and pollinated by hand. Table VII indicates the effectiveness of emasculation. It shows the amount of seed set when the florets were emasculated and bagged, no pollen being introduced.

Table IV.

Amount of seed set on spikes that were bagged.

Plant designation.	Species.	Year	No. of florets per spike.	No. of seeds. per spike.
t.1	A. tenerum	1926	12	12
t.2	"	"	12	11
t.3	"	"	12	11
t.4	"	"	12	10
t.5	"	"	12	10
t.6	"	"	12	9
t.7	"	"	12	10
S.1	A. Smithii	"	20	15
S.2	"	"	20	17
S.3	"	"	20	17
R.1	A. caninum	"	15	14
R.2	"	"	15	13
R.3	"	"	15	12
R.4	"	"	15	12
c.1	A. crystatum	"	20	18
c.2	"	"	20	19
c.3	"	"	20	18
r.1	A. repens	"	15	13
r.2	"	"	15	12
r.3	"	"	15	12
r.4	"	"	15	14

Table V.

Amount of seed set on emasculated exposed spikes.

Plant designation.	Species.	Year.	No. of florets per spike.	No. of seeds per spike.
t.12	A. tenerum	1926	15	1
t.13	"	"	15	0
t.14	"	"	10	1
t.15	"	"	30	2
t.16	"	"	18	0
t.17	"	"	20	1
t.18	"	"	23	0
t.19	"	"	30	2
t.20	"	"	23	1
t.1	"	1927	16	1
t.2	"	"	12	0
t.3	"	"	17	0
t.4	"	"	15	1
t.5	"	"	22	0
t.6	"	"	18	0
t.7	"	"	16	0
t.8	"	"	24	1
t.9	"	"	21	0
t.10	"	"	18	1
t.11	"	"	23	0

continued

Plant designation.	Species.	Year.	No. of florets per spike.	No. of seeds per spike.
S.7	A. Smithii	1926	11	2
S.8	"	"	9	4
S.9	"	"	10	2
S.10	"	"	10	1
S.11	"	"	15	3
S.12	"	"	15	4
S.13	"	"	15	6
S.14	"	"	15	7
S.15	"	"	15	14
S.16	"	"	48	26
S.17	"	"	47	27
S.18	"	"	14	5
S.19	"	"	10	3
S.1	"	1927	34	14
S.2	"	"	40	16
S.3	"	"	21	8
S.4	"	"	70	30
S.5	"	"	27	12
R.9	A. caninum	1926	26	2
R.10	"	"	25	0
R.11	"	"	18	1
R.12	"	"	35	2
R.13	"	"	22	0
R.14	"	"	36	1

continued.

Plant designation.	Species.	Year.	No. of florets per spike.	No. of seeds per spike.
R.1	A. caninum	1927	12	0
R.2	"	"	18	1
R.3	"	"	14	0
R.4	"	"	28	0
R.5	"	"	24	0
R.6	"	"	22	2
R.7	"	"	27	1
R.8	"	"	25	0
R.9	"	"	12	0
R.10	"	"	14	1
c.7	A. crystatum	1926	52	1
c.8	"	"	48	1
c.9	"	"	45	0
c.10	"	"	40	0
c.11	"	"	27	0
c.1	"	1927	65	1
c.2	"	"	31	0
c.3	"	"	27	1
c.4	"	"	16	0
c.5	"	"	61	2

continued.

Plant designation.	Species.	Year.	No. of florets per spike.	No. of seeds per spike.
r.9	A. repens	1926	26	0
r.10	"	"	30	0
r.11	"	"	26	0
r.12	"	"	24	0
r.13	"	"	26	0
r.14	"	"	26	0
r.15	"	"	24	0
r.16	"	"	20	0
r.1	"	1927	51	2
r.2	"	"	62	0
r.3	"	"	31	0
r.4	"	"	23	0
r.5	"	"	25	1

Table VI.

Amount of seed set on hand-pollinated spikes.

Plant designation.	Species.	Year.	No. of florets per spike.	No. of seeds per spike.
t.8	A. tenerum	1926	12	7
t.9	"	"	12	8
t.10	"	"	12	6
t.11	"	"	12	7
t.12	"	1927	18	10
t.13	"	"	15	10
t.14	"	"	17	9
t.15	"	"	18	11
S.4	A. Smithii	1926	20	16
S.5	"	"	20	15
S.6	"	"	20	15
S.6	"	1927	32	19
S.7	"	"	16	10
S.8	"	"	18	11
R.5	A. caninum	1926	15	7
R.6	"	"	15	9
R.7	"	"	15	8
R.8	"	"	15	7

continued.

Plant designation.	Species.	Year.	No. of florets per spike.	No. of seeds per spike.
R.11	A. caninum	1927	14	9
R.12	"	"	16	8
R.13	"	"	20	12
R.14	"	"	18	11
c.4	A. crystatum	1926	20	17
c.5	"	"	20	17
c.6	"	"	20	15
c.6	"	1927	32	19
c.7	"	"	16	10
c.8	"	"	18	11
r.5	A. repens	1926	15	12
r.6	"	"	15	10
r.7	"	"	15	13
r.8	"	"	15	9
r.8	"	1927	19	16
r.9	"	"	22	10
r.10	"	"	12	9

Table VII.

Amount of seed set on bagged emasculated spikes.

Plant designation.	Species.	Year.	No. of florets per spike.	No. of seeds per spike.
t.21	A. tenerum	1926	20	0
t.22	"	"	15	0
t.23	"	"	18	0
t.15	"	1927	15	0
t.16	"	"	14	0
t.17	"	"	12	0
t.18	"	"	18	0
S.20	A. Smithii	1926	20	0
S.21	"	"	25	0
S.22	"	"	25	0
S.8	"	1927	48	0
S.9	"	"	47	0
R.15	A. caninum	1926	25	0
R.16	"	"	23	0
R.17	"	"	19	1
R.18	"	"	20	0
R.15	"	1927	18	0
R.16	"	"	21	1
R.17	"	"	17	0

continued.

Plant designation.	Species.	Year.	No. of florets per spike.	No. of seeds per spike.
c.12	A. crystatum	1926	28	0
c.13	"	"	27	0
c.14	"	"	32	0
c.9	"	1927	25	0
c.10	"	"	50	1
c.11	"	"	28	0
r.17	A. repens	1926	26	0
r.18	"	"	24	0
r.19	"	"	31	0
r.20	"	"	27	1
r.11	"	1927	28	0
r.12	"	"	32	1
r.13	"	"	40	0

Discussion.

In the foregoing data the number of plants involved in each determination is too small to warrant the computation of certain statistical constants. However, the number of florets is sufficiently large to give a fairly safe indication of what might be expected if the experiment were repeated. Therefore, these data are summarized and considered without the computation of either the standard deviation or the probable errors of the means. The original data are included so that the actual fluctuations may be observed. They also serve to make the general situation clear. Table VIII summarizes the data on pollination.

These data show no evidence of any self-sterility among the plants investigated, yet perhaps it is significant that A. Smithii set the lowest percentage of seed when hand-pollinated. When the plants were emasculated and exposed to wind-blown pollen it was found that A. Smithii developed seeds in 43.19 percent of the florets exposed. This could not have been the result of faulty emasculation because it is shown by table VII that the latter process was almost 100 percent effective. Under the same circumstances none of the other four species formed more than 3.3 percent. The small amount of seed set by A. tenerum, A. caninum, A. crystatum, and A. repens can be explained as the result of the chance lodging on the stigmas of pollen

Table VIII.

Summary of Pollination Investigation in Agropyron 1926-1927.

Species.	Fertility of selfed spikes. No. of florets.	% fertility.	Fertility of emasculated spikes. No. of florets.	% fertility.	Fertility of hand-pollinated spikes. No. of florets.	% fertility.	Fertility of emasculated bagged spikes. No. of florets.	% fertility.
A. tenerum	84	86.9	386	3.10	116	58.62	112	0.0
A. Smithii	60	81.66	426	43.19	126	68.25	165	0.0
A. caninum	60	88.33	333	3.30	116	61.29	143	1.39
A. crystatum	60	91.66	412	1.45	126	70.63	190	0.52
A. repens.	60	85.00	394	0.76	101	78.21	208	0.96

blown by the wind. The amount of seed set is too small to be regarded as the result of natural cross-pollination. But this will not explain the case of A. Smithii. Forty-three percent cannot be regarded as the result of chance. A. Smithii must possess some natural faculty which enables it to fertilize by wind-blown pollen. This may be safely regarded as an indication of natural cross-pollination. Under column four, table VIII is listed the percentage of seed formed by artificial cross-pollination within the species. It will be observed that the percentage-fertility increases from the top to the bottom of the column. Experience has shown that A. tenerum is very difficult to emasculate, the anthers being small and the filaments short. A. Smithii and A. crystatum are both easily emasculated, the anthers being large and well above the stigmas. Though A. caninum has small anthers they are more easily removed than those of A. tenerum, this is due to the stigmas being fairly small and the anther-filaments long in comparision to those of A. tenerum. A. repens has very large anthers and is very easily emasculated. The differences between colums two and four are probably the result of injury to the stigmas during emasculation.

It may, therefore, be concluded that under natural conditions A. tenerum, A. caninum, A. crystatum, and A. repens are self-fertilizing; while A. Smithii shows strong evidence

blown by the wind. The amount of seed set is too small t

is regarded as the result of natural cross-pollination.

But this will not explain the case of *A.* [illegible]. Thirty-

three percent cannot be regarded as the result of chance.

A. [illegible] must possess some natural faculty which enable

it to fertilize by wind-blown pollen. This may be safely

regarded as an indication of natural cross-pollination.

Under column four, TABLE VIII is listed the percentage of

seed formed by artificial cross-pollination within the

species. It will be observed that the percentage fertili-

increases from the top to the bottom of the column.

Experience has shown that *A.* [illegible] is very difficult to

emasculate, the anthers being small and the filaments sho

A. [illegible] and *A.* [illegible] are both easily emasculated,

anthers being large and well above the stigma. Though *A.*

[illegible] has small anthers they are more easily removed th

those of *A.* [illegible], this is due to the stigma being sm

small and the anther-filaments long in comparison to the

of *A.* [illegible]. *A.* [illegible] has very large anthers and is v

easily emasculated. The differences between column [illegible] a

four are probably the result of injury in the process of

emasculation.

It may, therefore, be concluded that under natural c

ditions *A.* [illegible], *A.* [illegible], *A.* [illegible], and *A.* [illegible]

of natural cross-fertilization, or at least the ability to be cross-fertilized. There is no indication of self-sterility, unless it be in A. Smithii. There is evidence to show that pollen from another plant is as effective in fertilization as pollen from the same flower.

SUMMARY.

Part I. Eight species of Agropyron have been studied in natural habitats in Alberta and Saskatchewan. Two introduced species have been studied under cultivation.

Agropyron tenerum was found growing wild in a wide range of habitats throughout the area investigated. Environment was not found to affect morphology. Wide variations in size, habit, and colour, were observed. Three conditions for awn length were found to exist. Indications of a correlation between height and awn length were found. A single plant was found with setulose leaf-sheaths.

A. caninum was found growing in many types of habitat. A wide range of awn lengths were found. Evidence points to the possibility of environment influencing morphology.

A. inerme was only found growing wild at one point. The evidence indicates a great similarity to A. caninum, and the possibility of A. inerme being an awnless form of the latter.

Two types of plant were found in A. repens; the first green in colour with very short awns, the second glaucous and long awned.

A. Smithii was found widely distributed, but showing little variation.

A. dasystachium was found widely distributed, and very prevalent in certain areas. Considerable variation in pubescence and awn length were found.

A. albicans was found in several places.

A. Griffithsii was found to be quite prevalent in certain areas.

The morphology of A. pungens and A. crystatum was studied.

Part II. The mode of pollination in five species of Agropyron has been investigated.

No strong evidence of self-sterility was found. A. tenerum, A. caninum, A. repens, and A. crystatum were found to be self-fertilizing. A. Smithii was found to possess the ability to form seed by natural cross-pollination.

ACKNOWLEDGMENTS.

The writer wishes to acknowlege the assistance given by the following: Professor J. R. Fryer, who has given much helpful advice and criticism both in the investigation and in the preparation of the manuscript; Dr. A. S. Hitchcock of the Smithsonian Institution, who identified doubtful specimens; the late Victor Matthews, of the Dominion Experimental Station, Scott Saskatchewan, who made available, for purposes of the investigation, fifty-six strains of Agropyron tenerum.

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